Dye-sensitized Chlorophyll Solar Cells Using Crude Chlorophyll Extract Coupled with Natural Cysteine-assisted Ag/Ppy Ion Carriers and Water Electrolyte

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Dye-sensitized Solar Cells (DSSCs) employ expensive Ru-sensitizers, toxic organic solvents and rare Pt catalyst in converting solar energy to electricity. In order to solve these disadvantages, we suggested the use of crude chlorophyll extract as the dye, using water as organic solvent's substituent, employing unprecedented Cys-Ag/PPy as cathode to replace Pt. Using hexane for chlorophyll extraction can promote dye adsorption onto TiO2 coating and enhance current by two-fold to 0.41 mAcm-2. Spectrophotometric analysis confirmed only chlorophyll showed significant adsorption. The dye is 398 times more cost-effective than the most common Ru dyes. Changing electrolyte from ethane-1,2-diol to acetonitrile, redox couple from KI to LiI and metal oxide from anatase TiO2 to anatase/rutile(1:1) TiO2 could give 0.84 mAcm-2. Incorporating Cys-Ag/PPy composite could yield 7.38 mAcm-2, compared to 0.84 mAcm-2 obtained by carbon black and 5.62 mAcm-2 by Ag/PPy composite. We reasoned that Cys-Ag/PPy facilitates interfacial charge exchange and enhance diffusion rate by hydrogen bonding developed between carboxyl group and triiodide. By UV irradiation on TiO2 coating, 89% current density was recovered when using water as electrolyte, compared to acetonitrile. This is the first report using three natural substitutes in making DSSCs. The dye and water are natural, non-toxic and abundant. Novel cysteine-assisted ion carriers reduce the need for heavy metal catalysts. Overall our device achieved 3.02% efficiency, 46% fill factor and 32.4 Wm-2 power density, which are one-third of Ru-based DSSCs. These substitutes can help commercialize DSSCs as a renewable energy in future and reduce environmental impact while harnessing solar energy.

Awards Won:
Third Award of $1,000